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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/559,757	04/27/2000	Yoshio ozawa	04329.2306	2923

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Finnegan Henderson Farabow Garrett & Dunner LLP
1300 I Street N W
Washington, DC 20005-3315

EXAMINER

MONDT, JOHANNES P

ART UNIT

PAPER NUMBER

2826

DATE MAILED: 01/29/2002

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary

Application No.

09/559,757

Applicant(s)

OZAWA ET AL.

Examiner

Johannes P Mondt

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-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 10 January 2002.
- 2a) ☒ This action is **FINAL**. 2b) ☐ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-5 and 7 is/are pending in the application.
- 4a) Of the above claim(s) _____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 1-5 and 7 is/are rejected.
- 7) ☐ Claim(s) _____ is/are objected to.
- 8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on _____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
- Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
- 11) ☐ The proposed drawing correction filed on _____ is: a) ☐ approved b) ☐ disapproved by the Examiner.
- If approved, corrected drawings are required in reply to this Office action.
- 12) ☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

- 13) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. _____.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
- * See the attached detailed Office action for a list of the certified copies not received.
- 14) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).
- a) ☐ The translation of the foreign language provisional application has been received.
- 15) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

- 1) ☐ Notice of References Cited (PTO-892)
- 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
- 3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s) _____
- 4) ☐ Interview Summary (PTO-413) Paper No(s). _____
- 5) ☐ Notice of Informal Patent Application (PTO-152)
- 6) ☐ Other: _____

DETAILED ACTION

Response to Amendment

Receipt of Amendment A filed 01/10/02 and entered as Paper No. 9 is acknowledged. In Amendment A, claim 6 has been canceled and all other claims have been amended. Therefore, claims 1-5 and 7 are pending at this time. Detailed response to remarks on claim rejections made by the examiner in the non-final (first) action are irrelevant as said remarks are directed to the new, amended claims, which are substantially different from the original claims. For purposes of clarification, the examiner has included a few comments in response to Applicants' remarks (see "Response to Arguments").

Claim Rejections - 35 USC § 103

1. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

2. ***Claims 1-4 are rejected*** under 35 U.S.C. 103(a) as being unpatentable over Rhee (5,646,054) in view of Teramoto (5,620,910).

With regard to claim 1, and with reference to Fig. 7: Rhee teaches a MOS transistor, which is a semiconductor device, comprising:

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(a) a semiconductor substrate 42 (column 4, lines 1-2) having a main plane which has a first region, bordering gate insulation film 60, and a second region, bordering oxide film 80, defined in a section taken along a direction of channel length; said second region having a surface that is lower than the surface of the first region, as evidenced by Fig. 7. Furthermore, the first region and the second region are connected to each other, because region 42 is contiguous. Also:

(b) a first gate insulating film 60 is formed on the first region (see column 4, lines 4-5);

(c) a gate electrode 62 containing silicon (in fact: made of polysilicon; see column 4, lines 5-6) is formed on 60; and

(d) an oxide film 80 (column 7, lines 13-14), arranged to be in contact with both the conductive film 62 and the first insulating film 60 (cf. Fig.7), is formed on the second region of the semiconductor substrate 42. Parenthetically, the difference between "oxide film" and "post oxide film" pertains to method of making hence is irrelevant for this device claim.

Rhee does not necessarily teach 60 to contain silicon, nitrogen and oxygen to take advantage of the dielectric properties of such materials, nor does Rhee teach 80 to contain silicon to take advantage of the good electrical insulation properties found among materials comprising both silicon and oxide. However, silicon oxynitride, a substance containing silicon, nitrogen and oxygen, has long been recognized for its excellent dielectric strength properties in connection with gate insulation layers, as

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evidenced by Teramoto, who teaches the application of SiO_xN_y as a thin gate insulation layer 506 (cf. Figs. 10C,F and column 18, lines 37-38); while Teramoto uses silicon oxide for the other insulation layers, and therefore it would have been an obvious advantage to select silicon oxynitride for this purpose. The examiner takes official notice that the use of silicon dioxide for field oxide components in the art of semiconductor devices has been well known to those of ordinary skills in the art for a long time. Therefore, it would have been obvious to one of ordinary skills in the art to modify the invention by Rhee at the time it was made so as to include silicon, nitrogen, and oxygen in 60, and so as to include silicon and oxygen in 80.

With regard to the further limitation of claims 2 and 3: as detailed above, Rhee does not teach 60 to contain nitrogen, and therefore, *a fortiori*, Rhee does not teach a portion of 60 that is in contact with the semiconductor substrate to contain nitrogen at a concentration higher than the concentration in a residual portion of the first insulating film, so as to create a barrier layer within the gate insulation film. However, Teramoto teaches (see Fig. 6) a nitrogen concentration profile in the gate insulation film 306 (506) that is higher in a portion of 306 (506) that is in contact with the (active layer of the) semiconductor substrate 304 (504) than it is in a residual portion in the mid section of the gate insulating film (see column 12, lines 1-8). Parenthetically it is noted that the active layer is part of the substrate by virtue of functional necessity. Therefore, it would have been obvious to one of ordinary skills in the art to modify the invention of Rhee at the time it was made so as to include a nitrogen concentration profile within the gate insulation layer such that said concentration is higher in a portion that is in contact with

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the semiconductor substrate than in a residual portion of the gate insulation layer (gate insulating film 60 of Applicant), that is: to incorporate Applicant's claim 2. The nitrogen concentration in the portion of the gate insulation film in contact with the semiconductor substrate as taught by Teramoto preferably ranges from 1 to atomic 30 %, and thus amply exceeds the limit of $5 \times 10^{13} \text{ cm}^{-2}$ for the concentration per unit surface of the interface. Thus, for the same reasons as given above, it would have been obvious to one of ordinary skills in the art to carry out abovementioned modification of the invention of Rhee in such as way as to select for the concentration of nitrogen in a portion of the gate insulating film in contact with the semiconductor substrate a value of $5 \times 10^{13} \text{ cm}^{-2}$ (*claim 3*).

With regard to claim 4: the examiner takes official notice that the function of nitrogen as used by Teramoto as detailed above under the discussion of claims 2 and 3 to create a diffusion barrier so as to prevent gate material to penetrate into the surrounding dielectric obviously has utility independent upon the direction into which said diffusion takes place, and that therefore the application of the same procedure as taught for the gate insulation film can be usefully inferred from the invention of Teramoto to be advantageous in the direction of the second insulating film as well. Therefore, it would have been obvious to one of ordinary skills in the art to modify the invention of Rhee so as to include nitrogen in the contents of 80 (see claim 2) and such that a portion of 80 that is in contact with the semiconductor substrate and the gate electrode has a (nitrogen) concentration higher than the concentration in the residual portion of the second insulating film.

3. **Claims 5** is rejected under 35 U.S.C. 103(a) as being unpatentable over Rhee and Teramoto as applied to claim 1 above, and further in view of Takemura (5,917,221). As detailed above, claim 1, on which claim 5 depends, is unpatentable over Rhee in view of Teramoto. Furthermore, the gate insulating film taught by Teramoto is a silicon oxide film containing nitrogen. Neither Rhee nor Teramoto teach the gate electrode to be made of a polycrystalline silicon film containing a dopant so as to increase the gate conductivity and thereby advantageously decrease the response time, although Rhee teaches the film to be made of a polycrystalline silicon film. However, the use of dopants to achieve this improvement is well known among those skilled in the art of active semiconductor devices, as evidenced by for instance Takemura, who teaches a field effect device with a phosphorus (n-type) doped polysilicon gate (see column 10, lines 22-27). Therefore, it would have been obvious to one of ordinary skills in the art to modify the invention essentially taught by Rhee and Takemura so as to select a silicon oxide film containing nitrogen for the gate insulating film and to include a gate electrode of polycrystalline silicon containing a dopant.

4. **Claim 7** is rejected under 35 U.S.C. 103(a) as being unpatentable over Rhee, Teramoto and Takemura as applied to claim 5 above, and further in view of Tomita et al (5,959,329). As detailed above, claim 5 (on which claim 7 depends) is unpatentable over Rhee, Teramoto, and Takemura, who, however, do not teach the gate insulating film as a tunnel gate insulating film to improve stress leak, dielectric breakage life, and

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charge trap amount characteristics, nor do they teach the conductive film as a floating electrode. However, silicon oxynitride tunnel gate insulating films are well-known in the art of oxide films for active semiconductor devices as shown by the U.S. Patent to Tomita et al, who teach a "tunnel oxide film" (see column 1, lines 6-8); however, the advantages of a silicon oxynitride film for the reasons given above (stress leak, dielectric breakage, charge trap amount characteristics) are clearly delineated (see column 2, 3-8). The examiner takes official notice that the same obviousness considerations as given above apply to a floating gate electrode as to any other gate electrode, with regard to the desirable material characteristics of the gate and its insulating surroundings, i.e., irregardless of whether the voltage is driven or floating, as enumerated above. Therefore, it would have been obvious to one of ordinary skills in the art to modify the invention essentially taught by Rhee, Teramoto and Takemura at the time it was made so as to equip the semiconductor device of claim 5 with a tunnel gate insulating film as the gate insulating film and a floating electrode as the gate electrode.

Response to Arguments

5. Applicant's arguments filed 01/10/02 have been fully considered but they are not persuasive. As mentioned above in "Response to Amendment", all claims have either been canceled (claim 6) or amended (claims 1-5 and 7), while Applicants' traverse, as formulated in their Remarks, are directed to the new claims. This makes it unnecessary to respond in detail to Applicants'. However, to foster understanding of the present Action the examiner wishes to point out that (1) a cross-section preferably should de

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defined with regard to a direction to which it is perpendicular rather than "along", because a cross-section has two directions in its plane. Furthermore, the cross-section of Applicants' embodiments (see for instance Figs. 3) is not essentially different from Fig. 7 in Rhee (loc. cit.), as evidenced by the view offered by both cross-sections of the source and drain to the left casu quo right of the paper drawing. It is therefore concluded by the examiner that the previous grounds for rejection have not been obviated by the change in language. Furthermore, the examiner wishes to point out the extensive arguments on the point of obviousness offered in the previous Action.

Conclusion

6. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

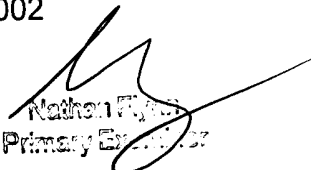
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Any inquiry concerning this communication or earlier communications from the examiner should be directed to Johannes P Mondt whose telephone number is 703-306-0531. The examiner can normally be reached on 8:00 - 18:00.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nathan J Flynn can be reached on 703-308-6601. The fax phone numbers for the organization where this application or proceeding is assigned are 703-308-7722 for regular communications and 703-308-7724 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-308-0956.

JPM
January 28, 2002


Nathan J. Flynn
Primary Examiner